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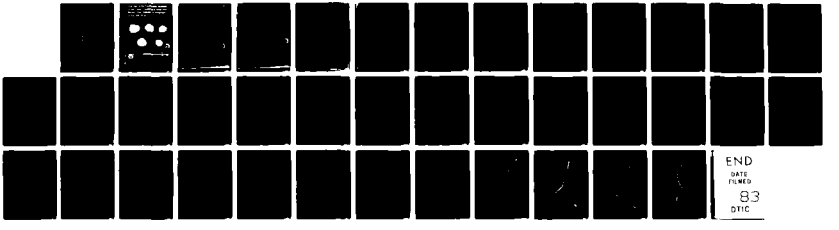

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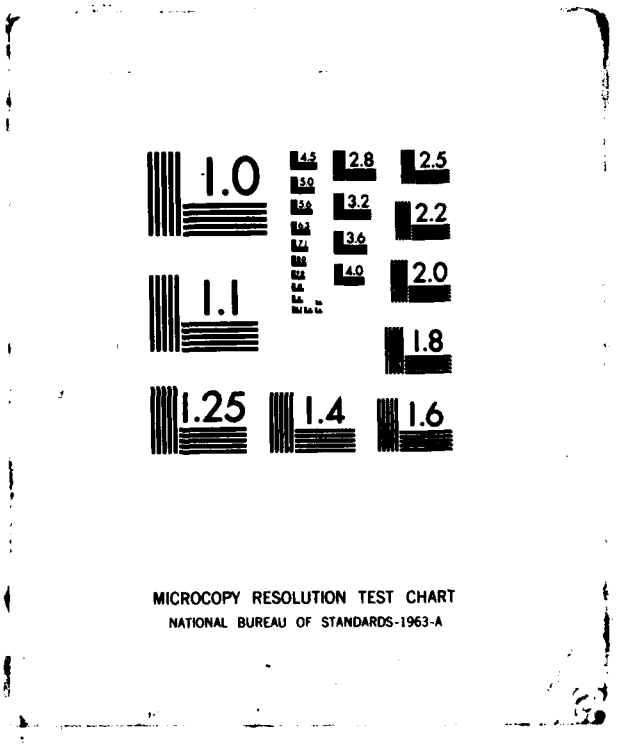

A Survey of the Freshwater Mussels of the Lower Cumberland River from Barkley Dam Tailwater Downstream to the Ohio River

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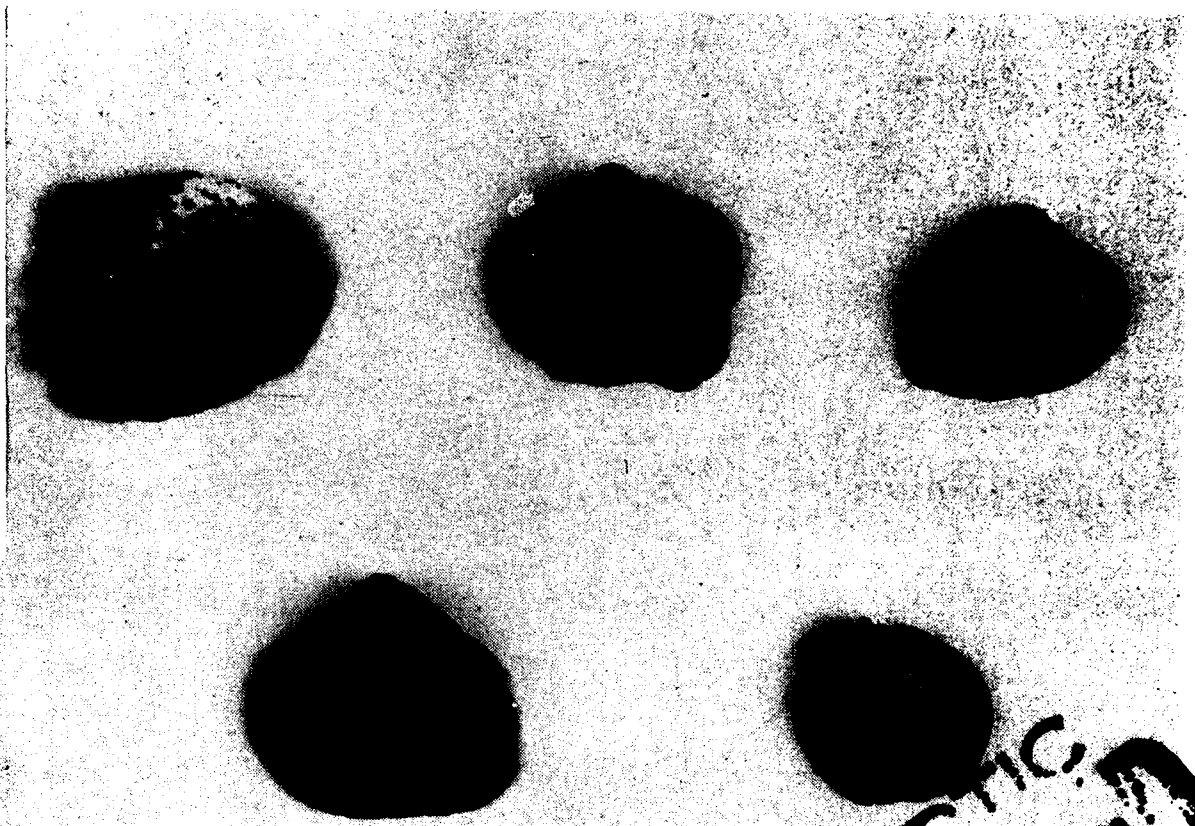

March 1982

US Army Corps
of Engineers
Nashville District

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A123717
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Survey of the Freshwater Mussels of the Lower Cumberland River from Barkley Dam Tailwater Downstream to the Ohio River.	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Sickel, James B.	8. CONTRACT OR GRANT NUMBER(s) Contract No. DACW62-81-C-0295
9. PERFORMING ORGANIZATION NAME AND ADDRESS Murray State University Foundation Murray State University - Spark Hall Murray, KY	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Engineer District, Nashville P.O. Box 1070 Nashville, TN 37202	12. REPORT DATE March, 1982
	13. NUMBER OF PAGES viii, 24
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release: Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Mussels
Barkley Dam
Cumberland River
Mollusca
Bivalvia
Unionidae
Tailwaters
Dredging

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

From 9 September through 8 November, 1981, a survey of freshwater mussels (Mollusca: Bivalvia: Unionidae) was conducted on the Cumberland River from mile 30, below Barkley Dam to the confluence of the Cumberland and Ohio Rivers to determine the species, location, relative density and habitat characteristics of mussels inhabiting the Barkley Dam tailwaters. Boats, equipped with 16 ft. mussel brails, were used to determine the locations and species composition of mussel beds, and scuba divers examined the beds to better sample the mussel fauna and determine sediment characteristics.

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Proposed dredging and disposal sites were examined to estimate the potential impact of Corps' navigation improvement activities upon the mussels.

Twenty-one species of mussels in 16 genera still survive in the lower Cumberland River. All but one of the most extensive mussel beds are not located within planned dredge or disposal sites. Mussel beds were found only in stable habitats which have probably been undisturbed for many years and which consist of gravel in a firm sandy-clay. Extreme daily fluctuations in discharge through the dam and high silt may have an adverse influence on reproduction and host fish distribution. Because the potential impact of dredging operations on downstream mussel beds is not known, it is recommended that a monitoring program be established to evaluate such impact.

A Survey of the Freshwater Mussels of the Lower Cumberland River from Barkley Dam Tailwater Downstream to the Ohio River

FINAL REPORT

A Survey of the Freshwater Mussels of the Lower Cumberland River from Barkley Dam Tailwater Downstream to the Ohio River

for the

Nashville District, United States Army Corps of Engineers

Contract No. DACW62-81-C-0295

Contractor: Murray State University Foundation
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March 19, 1982

ABSTRACT

From 9 September through 8 November, 1981, a survey of the freshwater mussels (Mollusca: Bivalvia: Unionidae) in the Cumberland River from Barkley Dam to the Ohio River was conducted for the Nashville District Army Corps of Engineers. The purpose of the survey was to determine the species of mussels inhabiting the Barkley Dam tailwaters, their locations, relative densities, and habitat characteristics. Brail equipped boats operated by commercial musselers were used to determine the locations and species composition of mussel beds, and SCUBA divers examined beds to more completely sample the mussel fauna and determine sediment characteristics. Proposed dredging and disposal sites were examined to estimate the potential impact of the Corps' navigation improvement activities upon the mussels.

The study area was the main channel, channel margins and shorelines from mile 30 on the Cumberland River below Barkley Dam to mile 0 at the confluence of the Cumberland and Ohio Rivers. Brail boats dragged 16 ft. mussel brails through the 30 mile section of the river. Three boats were generally used with one working in mid-channel and the other two working the channel margins. Trees and roots were too numerous to brail close to the shoreline, so SCUBA divers examined shallow areas where navigation improvement activities were proposed and in the vicinity of shell piles or mussel beds discovered by brailing. When mussel beds were encountered by musselers, several brail hauls were made to determine the limits of the beds.

Proposed dredge and disposal sites were described along with the mussel species, relative abundance, and the possible impacts of navigation improvement activities.

The general conclusions are as follows:

1. Twenty-one species of mussels in 16 genera still survive in the lower Cumberland River. Ten additional species in 8 genera were found only as relic shells. No live specimens of mussels listed on the Federal Endangered Species list were encountered, although relic or subfossil shells of 3 endangered species were found.
2. All but one of the most extensive mussel beds are not located within planned dredge or disposal sites. Only one major bed between miles 26.5 and 27.1, below Cooks Branch, is located within a proposed channel improvement site.
3. River bends where previous dredging activities may have occurred consist of loose sand and gravel providing an unstable habitat with few mussels. Mussel beds were found only in stable habitats which have probably been undisturbed for many years and which consist of gravel in a firm sandy-clay.
4. Judging by the age distribution of the mussels, recruitment for most species has not fared well during the 16 years since Barkley Dam was constructed. The reason for this is unknown, but the extreme daily fluctuations in discharge through the dam and high silt load may have an adverse influence on reproduction and host fish distribution.
5. Successful creation of new mussel habitat would be a tenuous enterprise in the Cumberland River. The only habitats where mussels are abundant, i.e., "mussel beds," occur in stable, nearly straight stretches of the river where the sediments are gravel in compact

sandy-clay. These sediments and beds have been stable for many years, some of the mussels being greater than 30 years old. Mussel recruitment is a slow process and any habitat disturbance such as shifting substratum can only retard the recruitment process. The most reasonable approach to perpetuating the mussels is to protect existing beds. Where dredging or other bend improvements have been conducted, the sediments are loose and unstable with few mussels even though some of the bends have not been altered for years. If it is desirable to attempt to create additional mussel habitat, a thorough study of the hydraulic characteristics of the river section of interest should be conducted at all flow stages. Perhaps dredging, filling, riprapping, or some other activity could be used to more or less permanently stabilize a section of river bed with a gravel bottom and sufficient current to prevent siltation at all river stages. This would create a suitable habitat into which adult mussels could be transplanted. Suitable fish hosts might also have to be stocked if none were present naturally. Extended monitoring could determine if the project were successful.

6. It is recommended that the mussels in the bed below Cooks Branch, CRM 26.5-27.1, be protected. If there is no alternative to dredging, then an attempt should be made to relocate the mussels. This could only be accomplished by divers who could carefully remove each mussel from the substrate to prevent injury and replace each in the proper orientation in a suitable habitat.

7. Because the potential impact of dredging operations on downstream mussel beds is not known, it is recommended that a monitoring program

be established to evaluate such impact. Several downstream beds should be studied with the aid of SCUBA divers before, during, and after upstream dredging operations to determine the impact of suspended sediments and associated environmental perturbations.

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ACKNOWLEDGEMENTS

Many thanks are extended to Dr. David H. Stansbery, Ohio State University Museum of Zoology, who assisted in the identification of mussels collected in this project. Any errors or names not consistent with those recognized by Dr. Stansbery are the responsibility of the author. Many individuals deserve special appreciation for their assistance on the project. The diving team consisted of Carol C. Chandler, Garry L. Pharris and the author with assistance from Mark F. Boone and Phil Chandler. Mussel brailing was conducted primarily by Norris E. Jones and Rudy D. Bridges. This project could not have been conducted without the assistance and financial support of the Nashville District Army Corps of Engineers. This support is greatly appreciated.

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FINAL REPORT

A Survey of the Freshwater Mussels of the Lower Cumberland River from Barkley Dam Tailwater Downstream to the Ohio River

1. Introduction

There has been only one published investigation of the mussel fauna of the lower Cumberland River including the region inundated by Barkley Lake (Wilson and Clark, 1914, The Mussels of the Cumberland River and Its Tributaries). In 1911 the biological team from the U.S. Biological Station at Fairport, Iowa, surveyed the Cumberland River from Kuttawa, Kentucky, to Cumberland Falls. They reported extensive mussel beds throughout the river supporting a prosperous button industry. The effect of dams on mussels was indicated in the description of the mussel beds of Harpeth River. The backwater from Dam A, river mile 150.6, had killed a large mussel bed five miles up the Harpeth River (Wilson and Clark, 1914).

From the present location of Cheatham Dam, mile 148.7, to Barkley Dam, mile 30.6, Wilson and Clark (1914) reported collecting at 28 locations. No collections were made below Horse Ford near Kuttawa, mile 36. Therefore, there is no record of the mussel fauna from Barkley Dam to the Ohio River.

Wilson and Clark (1914) reported 26 species of mussels in the lower Cumberland below mile 148. Three of the 26 are listed on the Federal Endangered Species List: Epioblasma (=Dysnomia) florentina,

Lampsilis orbiculata, and Plethobasus cooperianus. Epioblasma florentina was found only as a dead shell of a female at Half Pone Bar, mile 145.5. It is unlikely that it exists in the lower section of the Cumberland today. Lampsilis orbiculata was found at Seven-mile Ferry, mile 132, and at Kuttawa, mile 41. If extensive mussel beds exist below Barkley Dam as they do below Kentucky Dam in the Tennessee River, it is possible that L. orbiculata still survives there as it does in the Tennessee River. Plethobasus cooperianus was reported from Owl Hollow Bar, c. mile 129-130; Geisers Bar, mile 128-129; Clarksville, mile 126; Red Rock Bar, below Clarksville, c. mile 125-126; Meeks Spring Bar, c. mile 117-119; Walters Camp, c. mile 98; above and below Ball Island, mile (?); Linton, Kentucky, mile 73; Donaldson Creek, mile 68; Canton, Kentucky, mile 63; and Horse Ford below Kuttawa, mile 36. At Walter's mussel camp, about mile 98, Wilson and Clark reported a pile of approximately 150 tons of shells with Plethobasus cooperianus ranked second in abundance of the commercial species.

Since the demise of the pearl button industry, the lower Cumberland River has seen few clammers. When the demand for shells for the cultured pearl industry sent clammers back to the rivers, it was discovered that Cumberland River shells were too chalky or badly eroded and had a low value as pearl nuclei. Below Barkley Dam the swift current, inaccessability of landings, and low value of shells has kept clammers away. Therefore, nothing is known about the recent mussel fauna.

2. Methods

The survey was conducted using 3 commercial mussel boats equipped

with 16 ft. brails and operated by commercial musselers. A johnboat equipped with an 8 ft. brail and operated by Murray State University personnel was also used. Three SCUBA divers sampled selected sites where proposed dredging or disposal is to occur. Also, sites where brails were not effective, such as among rocks and snags, mussel beds discovered by brailing and the vicinity of shell piles were examined by divers. The commercial musselers brailed the middle, right and left margins of the channel from river mile 30 to the Ohio River. Where mussels were encountered in significant numbers, several brail hauls were made to more fully determine the location and extent of the beds and the species composition. SCUBA diving on mussel beds was used to determine sediment characteristics and to search for mussel species not caught by the brails. Representative samples of brail catches and all SCUBA samples were counted to determine the relative abundance of species. Other brail samples were examined only for species composition.

3. Dredge and Disposal Site Characteristics

The following site descriptions are of proposed dredging or disposal sites. Included in each description is a general characterization of the substrate determined by SCUBA divers and a discussion of the mussels found within the boundaries of the sites. The site designations and locations are given in terms of Cumberland River miles, CRM, and right or left banks (facing downstream). Potential impacts of navigation improvement activities are noted.

CRM 4.6 - 4.9, Left. Dredge site extends from CRM 4.7 - 4.9 with disposal at CRM 4.6. The proposed dredge site is a point of rock and hard clay extending out from the left bank at the mouth of

Ferguson Creek. The bank slopes sharply to an elevation of 289 ft. and consists of hard clay with some gravel. No live mussels were found at the dredge site. The disposal site at CRM 4.6, Left, is a deep hole, elevation 284 - 274 ft., with a substrate consisting of compact mud and gravel. No live mussels and only shells of Proptera alata, Proptera laevissima, and Arcidens confragosus were found.

However, in the mid-channel from CRM 4.7 - 5.0 an extensive bed of washboards (Megalonaias gigantea) occurred with 13 other species (Table 1). If navigation improvement activities are confined to the designated site, this bed should remain undisturbed. Disposal should occur close to the left bank to avoid covering the mid-channel bed.

CRM 17.5 - 17.9, Right. This disposal site parallels a rocky shore. A steep rock bank extends to the river bottom at an elevation of 270 - 275 ft. which also consists of rock. No mussels were found along this bank or river bottom. The site appears to be a good disposal site for gravel, but apparently a strong current scours the bottom at high water. It is doubtful that fine materials would remain at the site, and the effect of suspended silt and sand on the mussel beds downstream should be considered. The nearest downstream bed is located at CRM 17, Left, across from Clay Lick Creek (Table 1).

CRM 19.8 - 20.1, Left. This dredge site includes most of the bend across from Dycusburg, Ky. The left or inside bank possesses many uprooted trees and the right bank is rocky; therefore, brailing was only possible in mid-channel. Scattered mussels were found in water about 20 ft. deep, elevation 284 ft. In the dredge site, the inside of the bend, the substrate was gravel in clay and silt. It appeared

relatively stable but contained only a few mussels. Only 1 Anodonta grandis, 1 Quadrula quadrula and 3 Proptera alata were found by divers (Table 1). Dredging would directly affect only a small number of scattered mussels. No bed occurs at this site. The nearest bed is located at CRM 20.0 - 20.2, Right, and scattered mussels occur in mid-channel from CRM 17.5 - 19.6. These mid-channel mussels might be affected by silt suspended during dredging operations.

CRM 23.1 - 23.5, Right. This disposal site was a mud bank sloping to an elevation of 280 - 284 ft. with a bottom substrate of loose silt and sand layered over gravel. The loose, unstable substrate has apparently prevented recruitment of mussels. Only 4 mussels were found by divers. Fine materials disposed here would tend to remain in place and no mussel bed would be covered. There are scattered mussels along the left margin of the channel so that area should be avoided.

CRM 24.0 - 24.6, Left. This dredge site has apparently been dredged in the past. It is a depositing region and the substrate consists of loose gravel covered with a layer of sand several cm deep. The sand was formed into dunes and was obviously unstable and not conducive to mussel recruitment. Only 2 live mussels and a few dead shells were found by divers. Scattered mussels were found in mid-channel. Continued dredging at this site will prevent successful recruitment that might otherwise occur if the substrate stablizes.

CRM 25.0 - 25.2, Left. This disposal site across from Feinklestein Branch has a hard clay bank and is deep. No mussels were found.

CRM 25.4 - 26.0, Right. The shallow, sloping bank of this dredge site was mud that changed into a loose sandy-gravel bottom at a depth of 10 ft. (elevation 294). No mussels were found in the gravel out from shore, and only 1 Quadrula nodulata and 2 Leptodea fragilis were found near shore. Dredging this site would impact few mussels.

CRM 26.9 - 27.3, Right. This dredge site should be considered carefully. Judging from the mussel composition it has not been dredged in the past. There is an extensive mussel bed within and just below the site. Throughout the dredge site the bank is firm clay sloping at about 40° to a stable bottom of gravel in firm sandy-silt. Beginning at CRM 27.3 the bottom is at an elevation of about 294 ft. and slopes to about 280 ft.at CRM 26.9. An extensive mussel bed extends from the bottom of the clay bank out to mid-channel throughout this area. By diving and brailing at this site 15 species were collected. This mussel bed is the first bed downstream from Barkley Dam and ranks third largest in the entire tailwater section. Because of the downward slope of the bed, dredging in the shallower, upstream portion of the site might cause the lower portion to be covered, resulting in the destruction of the entire mussel bed. Widening the left channel margin might be considered as an alternative to dredging the mussel bed since few mussels were found left of mid-channel.

CRM 27.5 - 27.8, Left. This disposal site is a sandy-gravel bar that appears to have been created by dredge spoil. There are few exposed gravel bars in the lower Cumberland River. Superficially it looks like good mussel habitat, but upon closer examination the gravel and sand were found to be unstable, and only 2 live mussels were collected.

Many subfossil shells were found, however, including Lampsilis orbiculata, Plethobasus cicatricosus, Obovaria retusa, and Epioblasma flexuosa. Continued disposal at this site would not affect any existing mussel beds.

CRM 28.2 - 28.5, Right. Flat Creek enters the Cumberland River at mile 28.35 through steep, muddy, clay banks. A soft bar of sandy-silt extends along the right bank from CRM 29.0 to CRM 28.2 approaching the sharp bend at Camp Rowdy Landing. On one of the three days this site was sampled, a towboat with barges headed downstream had to back upriver three times before negotiating the bend. Only 1 live mussel was found, Proptera alata, in dive samples paralleling the shore for 100 m, and it was in mud near shore. Many dead shells were found indicating that this site is unsuitable as a mussel habitat. This is also indicated by the soft substrate deposited over gravel. Dredging this site would impact only a small number of mussels; however, a large quantity of silt could be suspended which might have an adverse influence downstream.

CRM 30.07 - 30.2, Right. This dredge site is at the base of shoreline riprap. No mussels were found and no impact on mussels is predicted from dredging activities at this site.

4. Lower Cumberland Mussel Beds

The distribution of all mussels found during the survey is presented in Table 1. The location of beds is indicated by solid areas on the accompanying maps, and scattered mussels are indicated by dots.

Mussel beds are considered to be locations of stable substrate, usually of gravel and sand in compact silt and clay, in which mussels

of various age classes and species occur in significant densities, generally more than $1/m^2$. The establishment of a bed requires many years since mussel recruitment is generally a slow process. It is not uncommon to find beds composed of individuals ranging from 5 - 25 years in age and very few juveniles.

In the lower Cumberland River, the only bed that several retired musselers could recall as having ever produced commercial harvests was in the vicinity of Mile 14 between Pinckneyville and Sandy Creek. An old shell pile was located at CRM 14.3, Right, consisting mostly of "pinks," Elliptio crassidens, E. dilatata, and Cyclonaias tuberculata, and washboards, Megalonaias gigantea, which were the typically culled shells during pearl button days. Diving and brailing at the site revealed that the bed still exists and the limits are the mid-channel to the right bank from CRM 13.1 - 14.7. Nineteen species were found living in the bed which was the largest and most diverse in the Barkley tailwater section of the river. Fortunately, this bed is in a straight part of the river where no dredging is proposed. However, if a dam is placed further downstream which would impound this section of the river, many of the river species are likely to disappear. In fact, the age composition of the bed indicates that some of the river forms may already be on the verge of demise--most individuals being over 15 years old.

Other mussel beds were located at CRM 4.5 - 5.0, Middle, CRM 9.4 - 11.0, Middle, CRM 17.0 - 17.3, Right-Middle-Left, and CRM 26.5 - 27.1, Middle-Right. The bed at CRM 4.5 - 5.0 was confined to a narrow mid-channel region and consisted mainly of washboards, Megalonaias gigantea, with minor representatives of 13 other species. If dredging

could be restricted to the channel margin and bank, this bed could remain unharmed.

The bed at CRM 9.4 - 11.0 was rather spread out down the mid-channel. Fourteen species were represented with Fusconaia ebena being the most abundant and Meglonaias gigantea, Elliptio crassidens, and Pleurobema cordatum following in that order.

At CRM 17.0 - 17.3 a small bed was located in the vicinity of another old shell pile on the bank at CRM 17.3, Right. The bed was small but extended from bank to bank and contained 12 species.

The bed at CRM 26.5 - 27.1 was dense and extended from the bottom of the right bank out to mid-channel. Fifteen species were recovered alive along with dead shells of Obovaria retusa and Pleurobema rubrum. This bed is in danger of being destroyed if dredging is conducted as planned. Every consideration should be given to its protection.

Wilson and Clark (1914) reported 25 species of mussels from the lower Cumberland River in Kentucky from mile 36 - 73. A comparison of the species they found and the ones reported in the present study is presented in Table 2. Species found alive during the present study but not reported by Wilson and Clark for the lower river section include Anodonta grandis, Arcidens confragosus, Lasmigona complanata, Quadrula quadrula, Quadrula nodulata, and Truncilla donaciformis. Species reported by Wilson and Clark that were not found alive in this study are Quadrula fragosa, Cyclonaias tuberculata, Plethobasus cooperianus, Actinonaias ligamentina, Obovaria olivaria, Obovaria retusa, Proptera laevissima, Lampsilis ovata, and Lampsilis teres.

5. Relic Mussel Shells

Ten species of mussels obtained by divers occurred only as relic

or subfossil shells and were not found alive (Table 3). It is doubtful that the following 7 of these still survive within the tailwater section: Lampsilia orbiculata, Plethobasus cooperianus, Plethobasus cicatricosus, Pleurobema sintoxia, Pleurobema rubrum, Obovaria retusa, and Epioblasma flexuosa. The other three species, Cyclonaias tuberculata, Proptera laevissima and Anodonta imbecillis, probably still occur but in low numbers. Anodonta imbecillis may occur in ponds feeding tributaries of the main river and may occasionally wash into the main river. Cyclonaias tuberculata is abundant and reproducing in the Kentucky Dam tailwaters of the Tennessee River and was once abundant in the Cumberland River.

6. Locations of Shell Piles

Because of the steep, slumping banks of the lower Cumberland River, few shoreline sites occur where shells are likely to wash ashore. Only a few random shells were found on gravel bars or clay banks and most of these shells were of Corbicula.

Three large shell piles were located, each on the right bank and at miles 14.3, 17.3, and 19.5. The piles were mostly buried in the bank which had apparently slumped over them. Digging in the bank produced large numbers of shells, mostly "pinks," Elliptio crassidens, and washboards, Megalonaias gigantea. Pinks are shells with a pink or purple nacre which could not be sold for the pearl button industry, and so they were usually culled along shore to remove them from the harvest and beds. Washboards in the Cumberland were generally stained and low in value, so they too were frequently culled. Because of the species composition of thepiles, it is assumed that they are old cull piles from pearl button days 30 to 60 years ago. Each shell pile

occurs adjacent to existing mussel beds which supports the idea that the beds are very old. Some of the living mussels in these beds could well be greater than 30 years old.

7. Federal Endangered Species

Within the Barkley Dam tailwater section of the Cumberland River (mile 0 - 30.6) no live mussels have ever been reported that occur on the federal endangered species list. Wilson and Clark (1914) did not survey that section of the river, and the present study revealed no living endangered species.

The nearest recorded locations of endangered species are those of Wilson and Clark (1914) which now lie under Lake Barkley. Wilson and Clark reported finding Plethobasus cooperianus and Lampsilis orbiculata at locations upstream from mile 30.6, the present location of Barkley Dam. In the present study a single relic shell of Lampsilis orbiculata and of Plethobasus cooperianus as well as one relic value of Plethobasus cicatricosus were found. It is unlikley that any endangered species of mussels survive in the Barkley Dam tailwater.

8. Lower Cumberland Snails

Although the primary emphasis of this study was the unionid mussel, several species of gastropods were collected incidentally and are reported here because of their inclusion on the Kentucky endangered species list.

Gastropods were common on rocky substrates throughout much of the Barkley tailwater section of the Cumberland River. They occurred occasionally on large gravel and inside old mussel shells. The

largest populations of the river snails, Pleuroceridae, occurred on submerged limestone bluffs. Two pleurocerid snails found in this study are listed as rare and endangered in Kentucky (Branson, et al., 1981) and were candidates for listing on the federal endangered species list. The species are Lithasia armigera (Say, 1821) and Lithasia geniculata Haldeman, 1840 . Specimens of each were identified by Branley A. Branson and have been deposited in the collection at Eastern Kentucky University.

Healthy populations of Lithasia armigera were found at Cumberland River miles 16, 17.3, 26.9, and 27.1. This species appears to be able to survive the extensive diurnal fluctuations of water level and the turbidity characteristic of present lower Cumberland River waters. However, only a small population of Lithasia geniculata was found at mile 17.3. Its distribution within the Barkley tailwaters is restricted, and this species could be endangered there by additional environmental perturbations.

9. Conclusions

1. Twenty-one species of mussels in 16 genera still survive in the lower Cumberland River. Ten additional species in 8 genera were found only as relic shells. No live specimens of mussels listed on the Federal Endangered Species list were encountered, although relic or subfossil shells of 3 endangered species were found: Lampsilis orbiculata, Plethobasus cicatricosus, and Plethobasus cooperianus.
2. All but one of the most extensive mussel beds are not located within planned dredge or disposal sites. Only one major bed between miles 26.5 and 27.1, below Cooks Branch, is located within a proposed dredge and disposal site.

3. River bends where previous dredging activities may have occurred consist of loose sand and gravel providing an unstable habitat with few mussels. Mussel beds were found only in stable habitats which have probably been undistrubed for many years and which consist of gravel in a firm sandy-clay.
4. Judging by the age distribution of the mussels, recruitment for most species has not fared well during the 16 years since Barkley Dam was constructed. The reason for this is unknown, but the extreme daily fluctuations in discharge through the dam and high silt load may have an adverse influence on reproduction and host fish distribution.
5. Successful creation of new mussel habitat would be a tenuous enterprise in the Cumberland River. The only habitats where mussels are abundant, i.e., "mussel beds," occur in stable, nearly straight stretches of the river where the sediments are gravel in compact sandy-clay. These sediments have been stable for many years, some of the mussels being greater than 30 years old. Mussel recruitment is a slow process and any habitat disturbance such as shifting substratum can only retard the recruitment process. The most reasonable approach to perpetuating the mussels is to protect existing beds. Where dredging or other bend improvements have been conducted, the sediments are loose and unstable with few mussels even though some of the bends have not been altered for years. If it is desirable to attempt to create additional mussel habitat, a thorough study of the hydraulic characteristics of the river section of interest should be conducted at all flow stages. Perhaps dredging, filling, riprapping, or some other activity could be used to more or less permanently

stabilize a section of river bed with a gravel bottom and sufficient current to prevent siltation at all river stages. This would create a suitable habitat into which adult mussels could be transplanted. Suitable fish hosts might also have to be stocked if none were present naturally. Extended monitoring could determine if the project were successful.

6. It is recommended that the mussels in the bed below Cooks Branch, CRM 26.5 - 27.1, be protected. If there is no alternative to dredging, then an attempt should be made to relocate the mussels. This could only be accomplished by divers who could carefully remove each mussel from the substrate to prevent injury and replace each in the proper orientation in a suitable habitat.

7. Because the potential impact of dredging operations on downstream mussel beds is not known, it is recommended that a monitoring program be established to evaluate such impact. Several downstream beds should be studied with the aid of SCUBA divers before, during, and after upstream dredging operations to determine the impact of suspended sediments and associated environmental perturbations.

10. References

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TABLES AND FIGURES

Table 1. Distribution and abundance of mussels found by brailing and SCUBA diving in the lower Cumberland River from mile 30 to the Ohio River.

	CRM 4.7 - 5.0 Middle; Brail	CRM 9.0 - 9.3 Middle; Brail	CRM 9.4 - 11.0 Middle; Brail	CRM 10.6 Middle; Brail	CRM 11.0 - 12.4 Middle; Brail	CRM 13.5 - 14.0 Right, Middle; Brail	CRM 13.9 Right; Dive	CRM 13.9 Left; Dive	CRM 14.3 Right; Dive	CRM 17.0 Left; Brail	CRM 17.3 Right; Dive	CRM 17.5 - 19.6 Middle; Brail	CRM 19.6 Left; Dive	CRM 20.0 Left; Dive	CRM 20.0 - 20.2 Right; Brail	CRM 20.9 - 21.2 Right; Brail
Anodonta grandis	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Arcidens confragosus	3	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Lasmigona complanata	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Megalonaias gigantea	41	3	19	.	2	31	10	1	18	13	.	3	.	.	.	.
Tritogonia verrucosa	.	.	1	.	.	5	.	.	.	.	1	1	.	.	.	.
Quadrula quadrula	3	3	3	.	1	4	.	1	1	1	4	1	1	.	2	.
Q. metanevra	1	.	3	.	1	6	.	.	.	.	.	1	.	.	.	.
Q. nodulata	1	1	2	.	.	4	.	.	.	.	1	1	.	.	1	.
Q. pustulosa	1	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.
Amblema plicata	2	1	3	.	3	3	2	.	1	3	2	.	.	.	1	.
Fusconaia ebena	6	.	25	.	1	10	2	.	2	10	.	2	.	.	1	x
F. undata	1	.	1	.	.	.	1	.	.	.	.	x	.	.	1	.
Pleurobema cordatum	2	.	13	.	.	6	4	.	.	8	.	1	.	.	.	.
Elliptio crassidens	5	.	14	1	.	8	.	.	.	11	.	9	.	.	.	x
E. dilatata	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Obliquaria reflexa	3	4	.	.	5	5	.	.	2	3	.	1	.	.	.	.
Plagiola lineolata	4	.	4	.	.	6	.	.	.	3	.	.	.	.	.	.
Truncilla donaciformis	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Leptodea fragilis	.	.	1	.	.	.	.	.	.	1	.	1	.	.	.	.
Proptera alata	3	3	2	.	1	.	.	1	.	3	.	1	.	3	.	.
Ligumia recta	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Totals	76	16	93	1	15	90	23	3	24	56	8	22	1	4	6	x

Table 1 cont.

	CMR 22.5 - 22.8 Right; Brail	CRM 23.1 - 23.4 Left; Brail	CRM 23.3 Right; Dive	CRM 23.8 Middle; Brail	CRM 24.1 Middle; Brail	CRM 24.4 Middle; Brail	CRM 24.8 Right; Brail	CRM 25.5 Right; Dive	CRM 26.3 Middle; Brail	CRM 26.5 Middle; Brail	CRM 26.9 Right; Dive	CRM 27.1 Right; Dive	CRM 27.6 Left; Dive	CRM 28.5 Right; Dive
Anodonta grandis	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arcidens confragosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lasmigona complanata	.	.	.	.	.	.	.	.	.	.	3	2	.	.
Megalonaias gigantea	.	x	3	1	1	.	.	.	.	3	10	7	.	.
Tritogonia verrucosa	.	.	.	.	.	.	.	.	.	3	2	2	.	.
Quadrula quadrula	.	.	.	.	.	.	.	.	.	7	4	4	.	.
Q. metanevra	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Q. nodulata	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Q. pustulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amblema plicata	.	.	.	.	.	1	.	.	.	5	6	6	1	.
Fusconaia ebena	x	.	1	1	.	.	x	.	.	2	7	3	.	.
F. undata	.	.	.	1	.	.	.	.	.	1	1	2	.	.
Pleurobema cordatum	.	.	.	.	.	.	x	.	.	3	3	.	.	.
Elliptio crassidens	x	.	.	.	.	.	x	.	1	3	1	3	.	.
E. dilatata	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Obliquaria reflexa	.	.	1	.	.	.	.	.	1	1	.	.	.	.
Plagiola lineolata	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Truncilla donaciformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leptodea fragilis	.	.	.	.	.	.	.	2	.	.	1	.	.	.
Proptera alata	.	.	.	.	.	.	.	.	.	1	.	1	1	1
Ligumia recta	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Totals	x	x	5	3	1	1	x	3	2	33	39	30	2	1

Table 2. Mussels reported by Wilson and Clark (1914) from the lower Cumberland River in Kentucky, CRM 36-73, with common names, presently accepted names and occurrence in present study, CRM 0-30.

Wilson and Clark	Common Name	Presently Accepted Name	Occurrence in Present Study
Absent	Giant floater	Anodonta grandis Say, 1829	Live
Absent	Paper floater	Anodonta imbecillis Say, 1929	Shell
Absent	Rock pocketbook	Arcidens confragosus (Say, 1829)	Live
Absent	White heelspliter	Lasmigona complanata (Barnes, 1823)	Live
Quadrula heros	Washboard	Megalonaias gigantea (Barnes, 1823)	Live
Quadrula tritogonia	Buckhorn	Tritogonia verrucosa (Rafinesque, 1820)	Live
Absent	Mapleleaf	Quadrula quadrula (Rafinesque, 1820)	Live
Quadrula fragosa		Quadrula fragosa (Conrad, 1935)	Absent
Quadrula metanevra	Monkeyface	Quadrula metanevra (Rafinesque, 1820)	Live
Absent	Wartyback	Quadrula nodulata (Rafinesque, 1820)	Live
Quadrula pustulosa	Pimpleback	Quadrula pustulosa (Lea, 1831)	Live
Quadrula perplicata	Threeridge	Amblema plicata (Say, 1817)	Live
Quadrula ebenus	Ebony shell	Fusconaia ebena (Lea, 1831)	Live
Quadrula undata	Pigtoe	Fusconaia undata (Barnes, 1823)	Live
Quadrula tuberculata	Purple wartyback	Cyclonaias tuberculata (Raf. 1820)	Shell
Quadrula cooperiana	Cumberland pigtoe	Plethobasus cooperianus (Lea, 1834)	Shell
Absent	White wartyback	Plethobasus cicatricosus (Say, 1829)	Shell
Quadrula obliqua	Ohio River pigtoe	Pleurobema cordatum (Raf., 1820)	Live
Absent	Pigtoe	Pleurobema sintoxia (Raf. 1820)	Shell
Absent	Pink pigtoe	Pleurobema rubrum (Raf., 1820)	Shell
Unio crassidens	"pink," elephant ear	Elliptio crassidens (Lamarck, 1819)	Live
Unio gibbosus	Spike	Elliptio dilatata (Raf., 1820)	Live
Obliquaria reflexa	Three horned wartyback	Obliquaria reflexa (Raf., 1820)	Live
Lampsilis ligamentina gibba	Southern mucket	Actinonaias l. ligamentina (Lamark, 1819)	Absent

Table 2 continued

Wilson and Clark	Common Name	Presently Accepted Name	Occurrence in Present Study
Plagiola securis	Butterfly	*Plagiola lineolata* (Raf., 1820)	Live
Obovaria ellipsis	Hickorynut	*Obovaria olivaria* (Raf., 1820)	Absent
Obovaria retusa	Golfstick	*Obovaria retusa* (Lamarck, 1819)	Shell
Absent	Fawnfoot	*Truncilla donaciformis* (Lea, 1827)	Live
Lampsilis gracilis	Papershell	*Leptodea fragilis* (Raf., 1820)	Live
Lampsilis alata	Pink heelsplitter	*Proptera alata* (Say, 1817)	Live
Lampsilis laevissima	Pink papershell	*Proptera laevissima* (Lea, 1830)	Shell
Lampsilis recta	Black sandshell	*Ligumia recta* (Lamarck, 1819)	Live
Lampsilis ovata	Pocketbook	*Lampsilis ovata* (Say, 1817)	Absent
Lampsilis orbiculata	Pink mucket	*Lampsilis orbiculata* (Hildreth, 1828)	Shell
Lampsilis anodontoides	Yellow sandshell	*Lampsilis teres* (Raf., 1820)	Absent
Lampsilis fallaciosa	Slough sandshell	*Lampsilis teres* (Raf., 1820)	Absent
Absent		*Epioblasma flexuosa* (Raf., 1820)	Shell

Table 3. Mussels recovered only as shells and not found alive.

Species	River Mile	Date
Cyclonaias tuberculata	26.9 Right	10/7/81
Plethobasus cicatricosus	27.6 Left	9/9/81
Plethobasus cooperianus	17.3 Right	9/20/81
Pleurobema sintoxia	27.5 Left	9/9/81
Pleurobema rubrum	26.9 Right	10/7/81
Anodonta imbecillis	27.1 Right	10/8/81
Obovaria retusa	26.9 Right	10/7/81
Proptera laevissima	28.5 Right	10/8/81
Lampsilis orbiculata	27.5 Left	9/9/81
Epioblasma flexuosa	27.5 Left	9/9/81

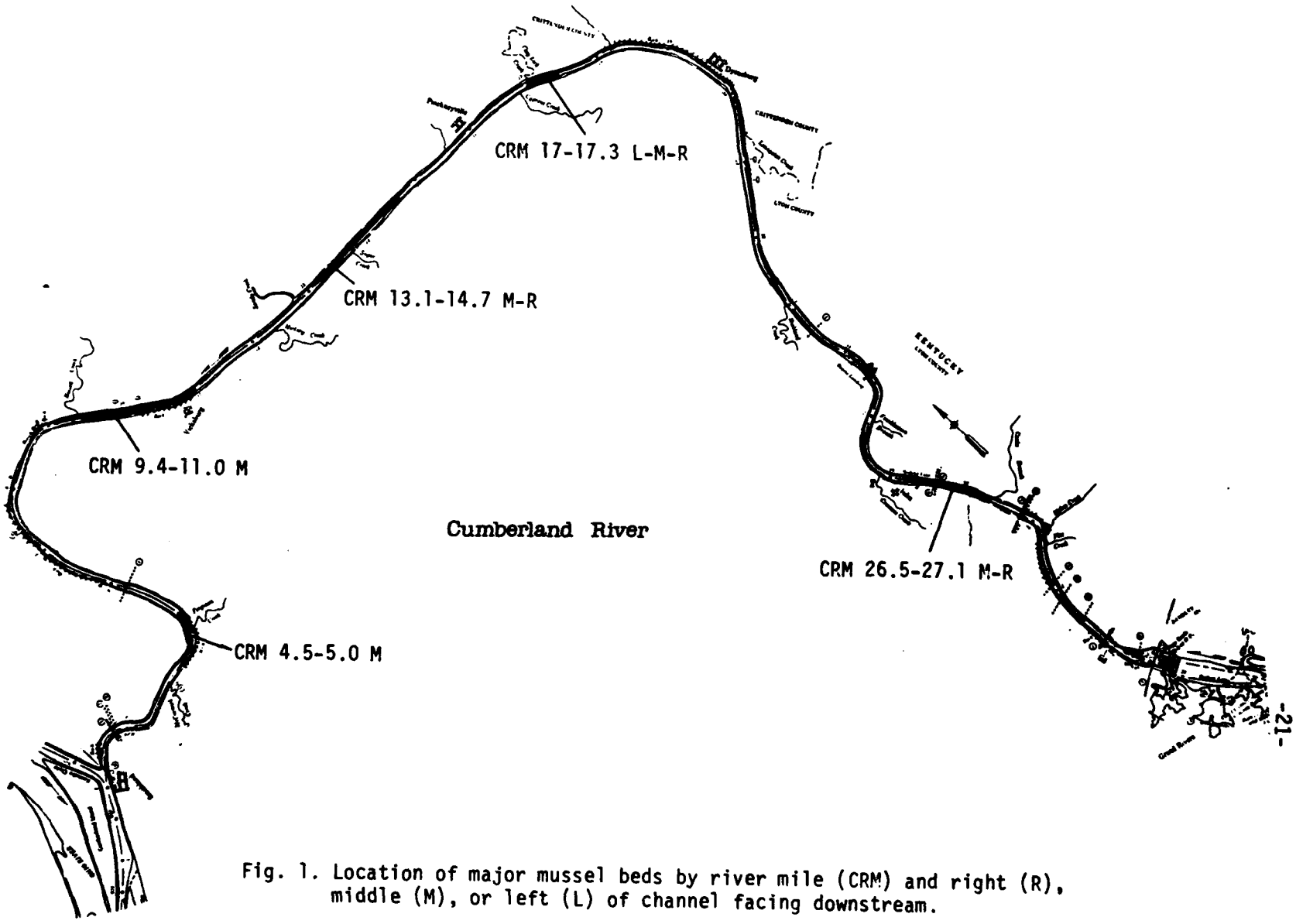

Fig. 1. Location of major mussel beds by river mile (CRM) and right (R), middle (M), or left (L) of channel facing downstream.

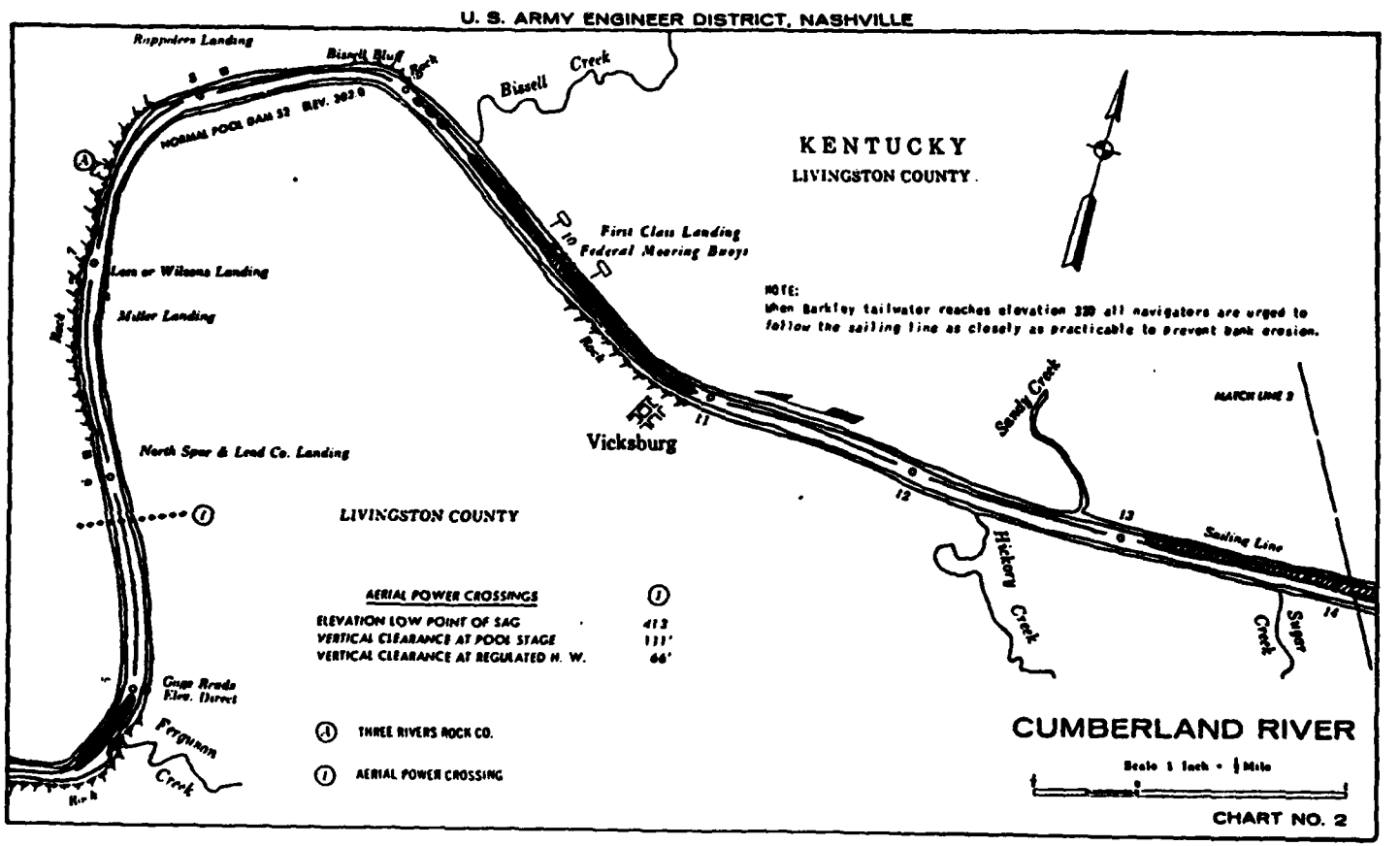

Fig. 2. Mussel beds indicated by hatched areas and scattered mussels indicated by hatched circles from miles 4.2-14.1.

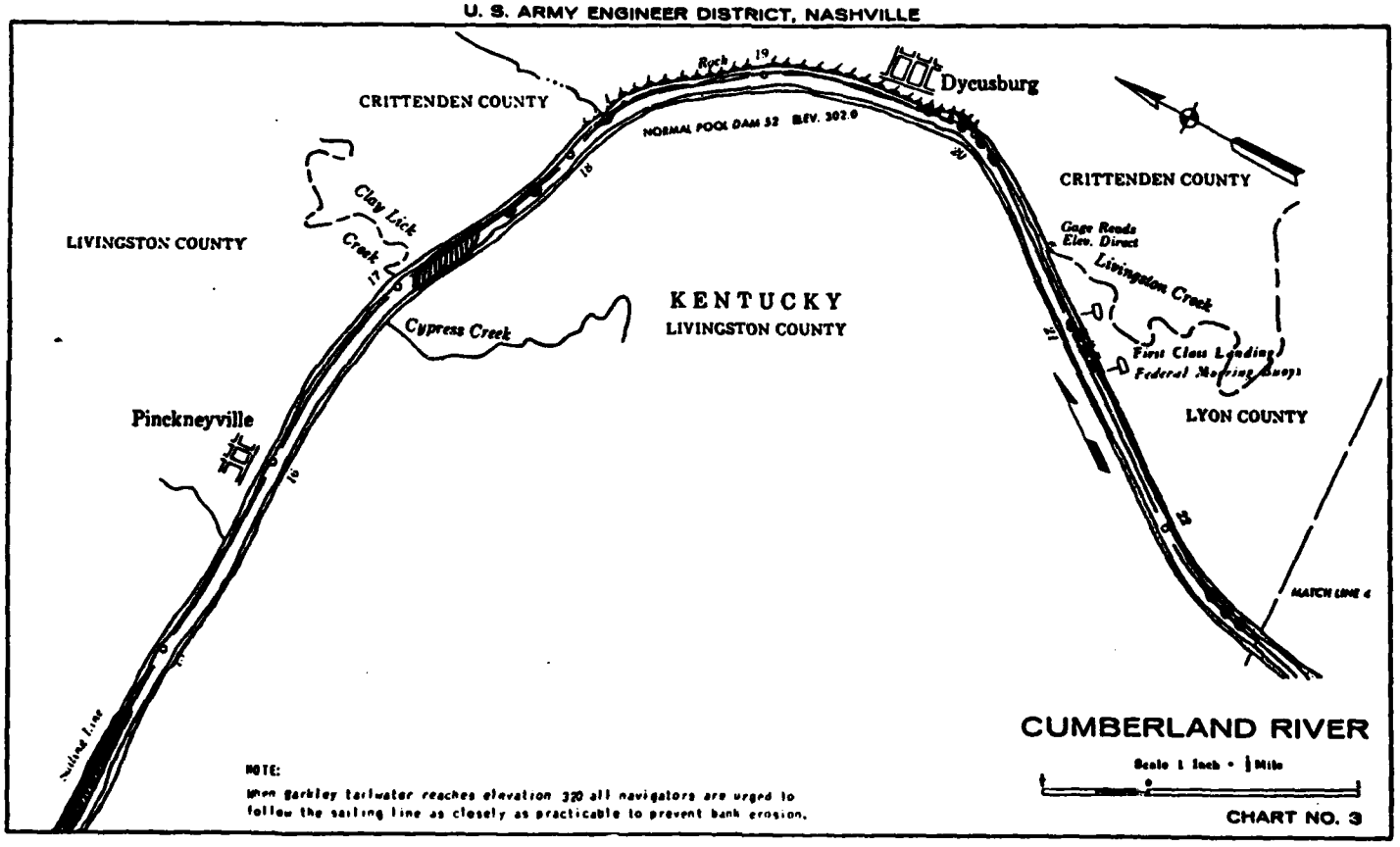

Fig. 3. Mussel beds indicated by hatched areas and scattered mussels indicated by hatched circles from miles 14.1-22.9.

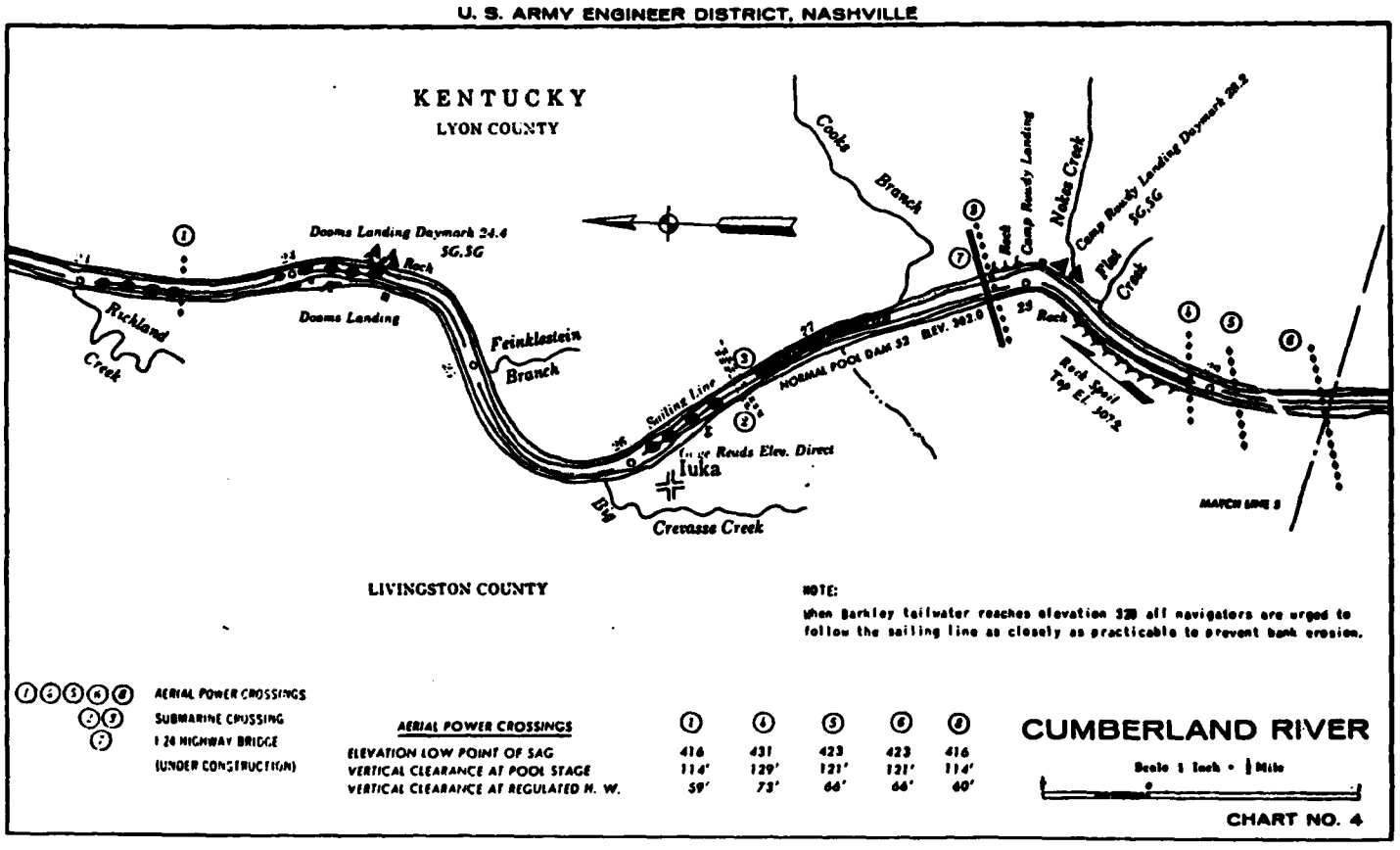

Fig. 4. Mussel beds indicated by hatched areas and scattered mussels indicated by hatched circles from miles 22.9-29.8.